# *Chromolaena odorata* in the Farming Systems of South-West Côte d'Ivoire.

(*Chromolaena odorata* dans les Systèmes de Production du Sud-Ouest de la Côte d'Ivoire)

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**Résumé**- Pendant une période d'étude s'étalant de 1979 à 1989, des observations ont été faites sur l'introduction et la diffusion de *Chromolaena odorata* dans le sud-ouest de la Côte d'Ivoire. Dans le système d'agriculture sur brûlis avec une saison de riz pluvial suivie par une jachère forestière de plus de 16 ans, *C. odorata* est supplantée par les arbres et lianes dont les graines étaient présentes dans le sol avant défrichement. Dans les régions où les périodes de jachères ont été réduites à moins de 6 ans, le nombre de graines d'arbres dans le sol diminue tandis que les graines d'herbacées s'accumulent. Dans ces régions, *C. odorata* devient une peste parce qu'elle remplace et domine la végétation naturelle des jachères. La culture du riz est alors remplacée par celle du mais et du manioc. La culture de riz pluvial, en alternance avec de courtes jachères se maintient uniquement dans les zones de sol mixte alluvial-marécageux où les rhizomes de *Marantaceae* restent dans le sol pendant la saison de culture. Les *Marantaceae* croîssent vigoureusement après la récolte du riz, empêchant le développement des adventices, y compris de *C. odorata.* D'autre part, les paysans plantent souvent des caféiers et des cacaoyers avec les cultures vivrières. Si la plantation est peu sarclée pendant les premières années, les adventices et *C. odorata* sont controlées par les composants arborés de la jachère. Par contre si les paysans sarclent leur plantation trop souvent, ils éliminent tous les plants d'arbres; ceux-ci sont alors remplacés par les adventices et par *C. odorata.* Les plantations où caféiers et cacaoyers sont morts évoluent en forêt secondaire dans le premier cas, et en fourré à *C. odorata* et graminées dans le second cas.

**Abstract**-During the study period of 1979 to 1989, observations were made on the introduction and spread of *Chromolaena odorata* through southwest Côte d'Ivoire. In the shifting cultivation system of one dry rice crop followed by more than 16 years of forest fallow, *C. odorata* is shaded out by trees and lianas whose seeds were present in the forest soil before clearing. In areas where the shifting cultivation system degenerates to short fallows under 6 years, the number of tree seeds in the soil diminishes while arable weed seeds accumulate in the soil. In these areas, *C. odorata* becomes a pest because it dominates and replaces the

natural fallow vegetation. Rice cultivation is substituted by maize and cassava. Dry rice cultivation alternating with short fallows continues only in areas with mixed alluvial-swampy soil where tubers of *Marantaceae* remain in the soil during the cropping period. These grow vigorously after the rice harvest, shading out arable weeds, leaving the fallow trees, but checking the installation of *C. odorata*. Farmers often plant cocoa or coffee along with foodcrops. If the plantation receives little weeding during the first years, arable weeds and *C. odorata* are controlled by the woody fallow vegetation. If farmers keep their plantations weeded, they eliminate all woody seedlings; these are replaced by arable weeds and *C. odorata*. Planted areas where cacao and coffee have died revert to secondary forest in the first situation, and to *C. odorata* thicket and grasses in the second.

## Introduction

The last region to be invaded in Côte d'Ivoire by *Chromolaena odorata* was the thickly forested area in the southwest. The plant was introduced to this part of Côte d'Ivoire in 1980, by machines used for road improvement in the northern part. Areas further south where no roadwork has been done remained uninfested probably up to 1986 (Gautier 1992). However, *C. odorata* invaded soon after most of the forest had been cut. High levels of forest cover in the northern part delayed *C. odorata* infestation of fields. It first appeared in rice fields in 1984. The level of *C. odorata* infestation in fields and its dominance in fallow vegetation depends largely on the agricultural system practiced.

## The Study Area

The study area, 5°57' - 5°20' N latitude and 7°30' - 7°14' W longitude, covers the agricultural zone between the Cavally River and the Taï National Park. It receives a mean annual rainfall of 1900 mm, falling primarily in two rainy seasons. Most food cultivation is performed in the heaviest rainy season from March through August. The land is undulating to sloping with severely leached, poor, acid, and often gravelly soils (Collinet *et al.* 1984, van Reuler & Janssen 1989).

The Taï National Park consists largely of undisturbed rain forest. Outside the Park, fields, patches of primary forest, secondary forest of different ages, and degraded vegetation form a mosaic. These primary and secondary forests have been studied by Alexandre *et al.* (1978), Guillaumet (1967) and Jaffré and de Namur (1983). Human-modified vegetation and land use have recently been described and mapped by de Rouw (1991).

The indigenous people of Oubi, Guéré and Krou slash and burn mature forest to crop it with rainfed rice for a season, then let it return to a forest fallow. Along with subsistence farming, cocoa and coffee are cultivated. Population pressure, widespread cocoa farming, and extension of the nearby National Park has resulted in reduction of fallow periods to about 6 years. This trend began in 1984 and has gained momentum since then.

The majority of the population consists of non-forest peoples, mainly Baoulé from central Côte d'Ivoire, and Mossi from Burkina Faso. They migrated to the region in the seventies and eighties to grow cocoa. They do not practice shifting cultivation with forest fallow. The main food crops of maize, yam and cassava are interplanted with cocoa. In some cases, maize is grown alternating with 2 to 4 years of fallow (Slaats 1992).

## Methods

Between 1979 and 1989, a total of 308 surveys were conducted among fields and young fallow vegetation. Fields chosen were thought to be representative of the region: shifting cultivation fields with rainfed rice as the dominant crop and fields under cocoa and various other food crops. Fields differed in cutting period, soils and forest cover. Each survey consisted of identifying all plants growing in a plot and counting the number of individuals per species, and describing the vegetation structure (cover and height per stratum). Where *C. odorata* was present, a differentiation was made between plants regenerating from seed or resprouting stumps. Plots covered 9 $m^2$ in rice fields (3 replications/ field), 18 $m^2$ in cocoa plantations (1 replication/field), and 36 $m^2$ in secondary forest. Environmental measurements included slope position, drainage, and soil profile description from auger samples of 1-120 cm depth. Crop history of the field was recorded and its surroundings were checked for possible seed sources.

## Results

Figure 1 schematically shows the estimated number of viable seeds buried in forest soil in relation to the number of years elapsed since the last clearing. The total number of seeds diminishes as the secondary forest gets older. The group of "arable weeds" are sub-woody, herbaceous, annual plants of open spaces, which deposit seeds during the last cropping period and have since perished into the forest regrowth. The group of "secondary forest plants" consists mainly of pioneer trees, lianas and some shade-tolerant herbs. Secondary forest trees start to produce seeds after a juvenile stage of 1 or more years, depending on the species. As a result, contributions made by woody species increase with age of the fallow, while arable weed seeds degrade in the soil. With time, pioneer trees are replaced by primary forest trees. Secondary forest trees produce continuously and copiously small, long-lived seeds, whereas primary forest species produce fewer seeds which are larger and generally short-lived (Swaine & Whitmore 1988). Thus the soil under primary forest contains few seeds

The lower portion of Figure 1 shows densities of plants appearing in fields at different ages, after fallow vegetation had been cleared. Seedlings were counted from non-weeded plots in the first six months after cutting. The relationship shown in Figure 1 corresponds with trends at other humid tropical sites (Garwood 1989).

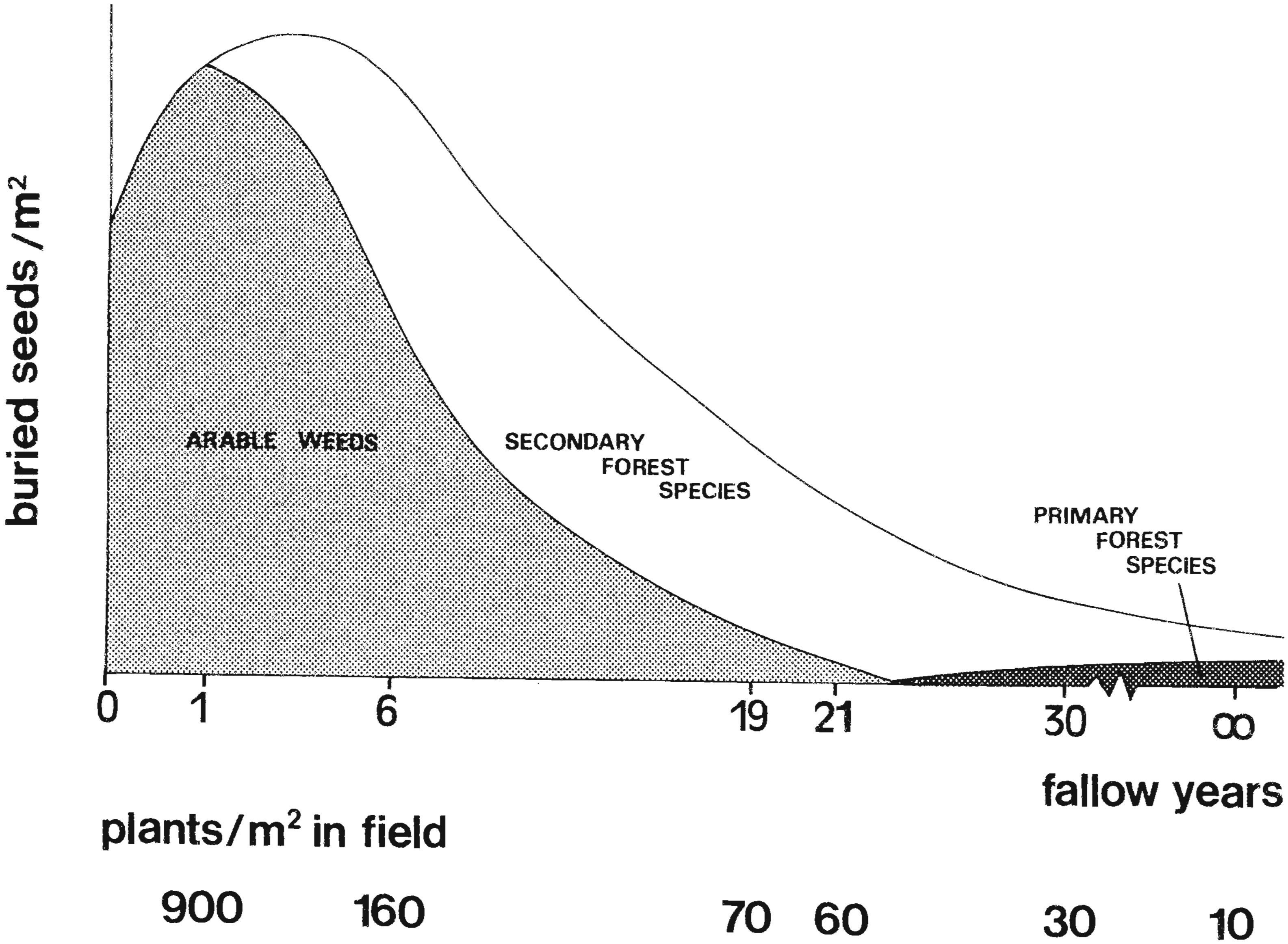


Figure 1. Density of arable weeds and secondary and primary forest species in relation to the length of fallow.

## Rice - Long Fallow Periods

After felling and burning secondary forests ranging between 16 and 30 years old, about half of the viable weed stock in the soil is lost (de Rouw & van Oers 1988). Other cultural practices helping to reduce weed growth include minimal tillage by dibbling the rice seeds into the top soil, which reduces the number of dormant weed seeds near the surface. Burning leads to instant mineralization of organic matter while ashes reduce soil acidity. Local varieties of rice are tall and vigorous plants (up to 1.8 m) with broad and droopy leaves which reduce sunlight required for germination of some weed seeds. However, *C. odorata* germinates with crop plants, annual weeds, pioneer trees and coppice from resprouting forest trees (Fig. 2).

The brief cultivation period allows annual weeds to produce just one seed crop before being choked in the forest regrowth. *C. odorata* may reach the canopy (2 - 4 m high) but is only able to produce one or two seed crops as it degenerates with the forest fallow growing thicker and higher.

## Rice - Short Fallow Periods

Many weed seeds remain viable during short fallow periods. During this time, less biomass is produced so less nutrients are liberated by burning. The fire is less intense and kills only a limited number of buried seeds. Rice plants are shorter, suffering from weed stress because arable weeds, more troublesome than tree seedlings, outnumber woody plants. *C. odorata* is able to occupy the general crown layer after the rice harvest. It gets firmly established and tends to form dense thickets suppressing other plants. Numerous seeds are produced annually resulting in a persistent seed bank.

Several cycles of rice cultivation and short fallow periods have considerably reduced tree seeds from the seed bank. Coppicing tree stumps have also become scarce under repeated cutting and burning. *C. odorata* dominates the natural fallow vegetation. After each clearing, vigorous sprouts are released from established plants and along with other arable weeds, seedlings are simultaneously recruited from the seed bank (Fig. 3). Rainfed rice cultivation becomes impossible so maize and cassava are planted instead. Because of its shorter cycle (3 instead of 5 months), maize escapes the heavy infestation by *C. odorata*. Cassava is preferred since it can be planted in smaller fields without reducing the caloric needs of the family.

In two small areas comprising 0.8% of the study area (640 ha), rainfed rice is grown for one season followed by a short fallow period not exceeding 6 years. Both areas are almost flat and the soil is a combination of valley bottoms and alluvial floodplains. Because of short fallow periods the seed bank consists mainly of arable weeds. Few seeds are destroyed by burning. Natural vegetation of these wet places include many Marantaceae and Zingiberaceae, which are stout, herbaceous climbing plants. Although these are cut back during the cropping period, they resprout from underground tubers at the end of the season. Their large leaves and vigorous growth assure a rapid ground cover, thus preventing the spread of heliophil weeds like grasses, sedges and annual dicots. However, neither

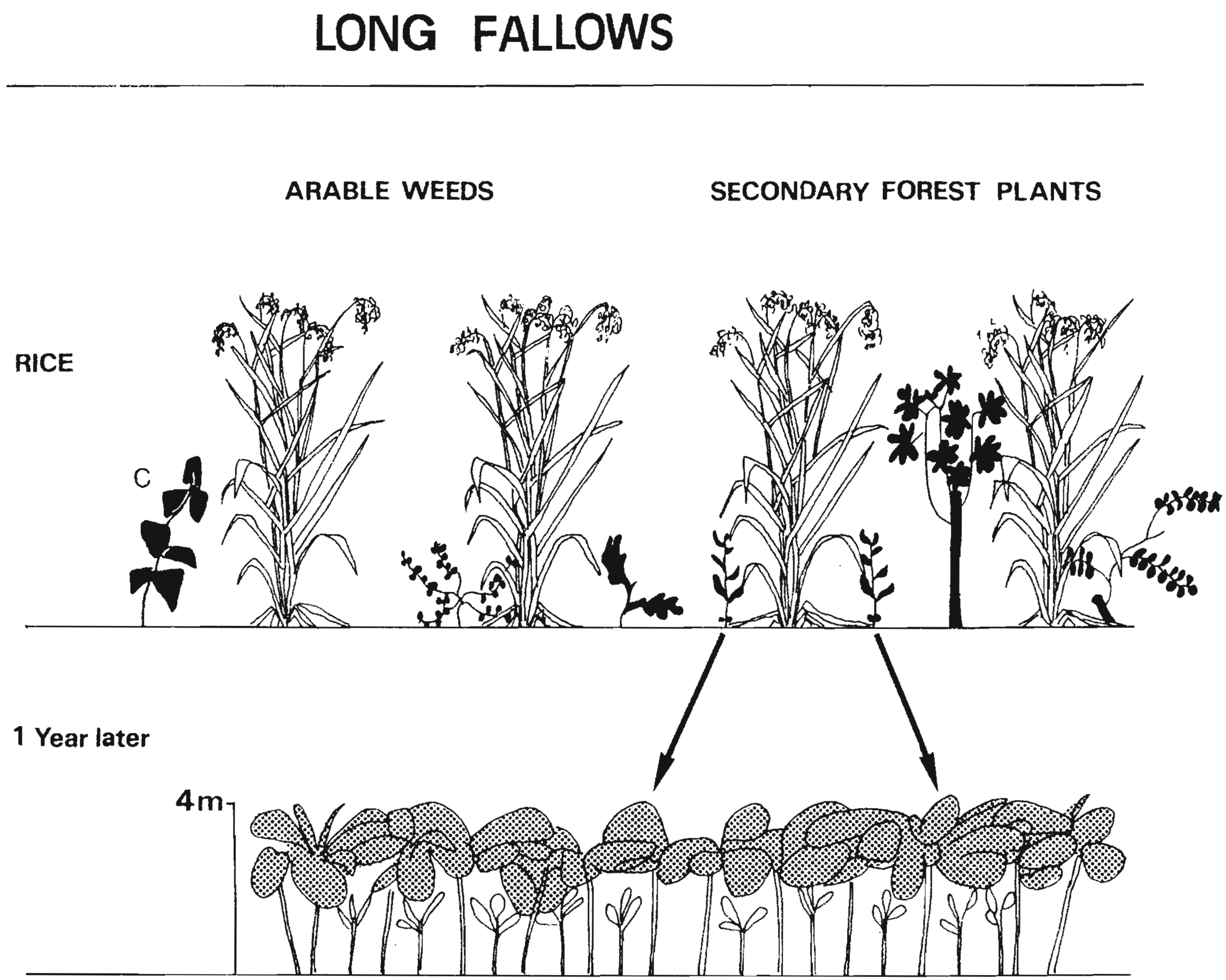


Figure 2. Spontaneous plant growth in Rice planted in a 16 year old fallow.

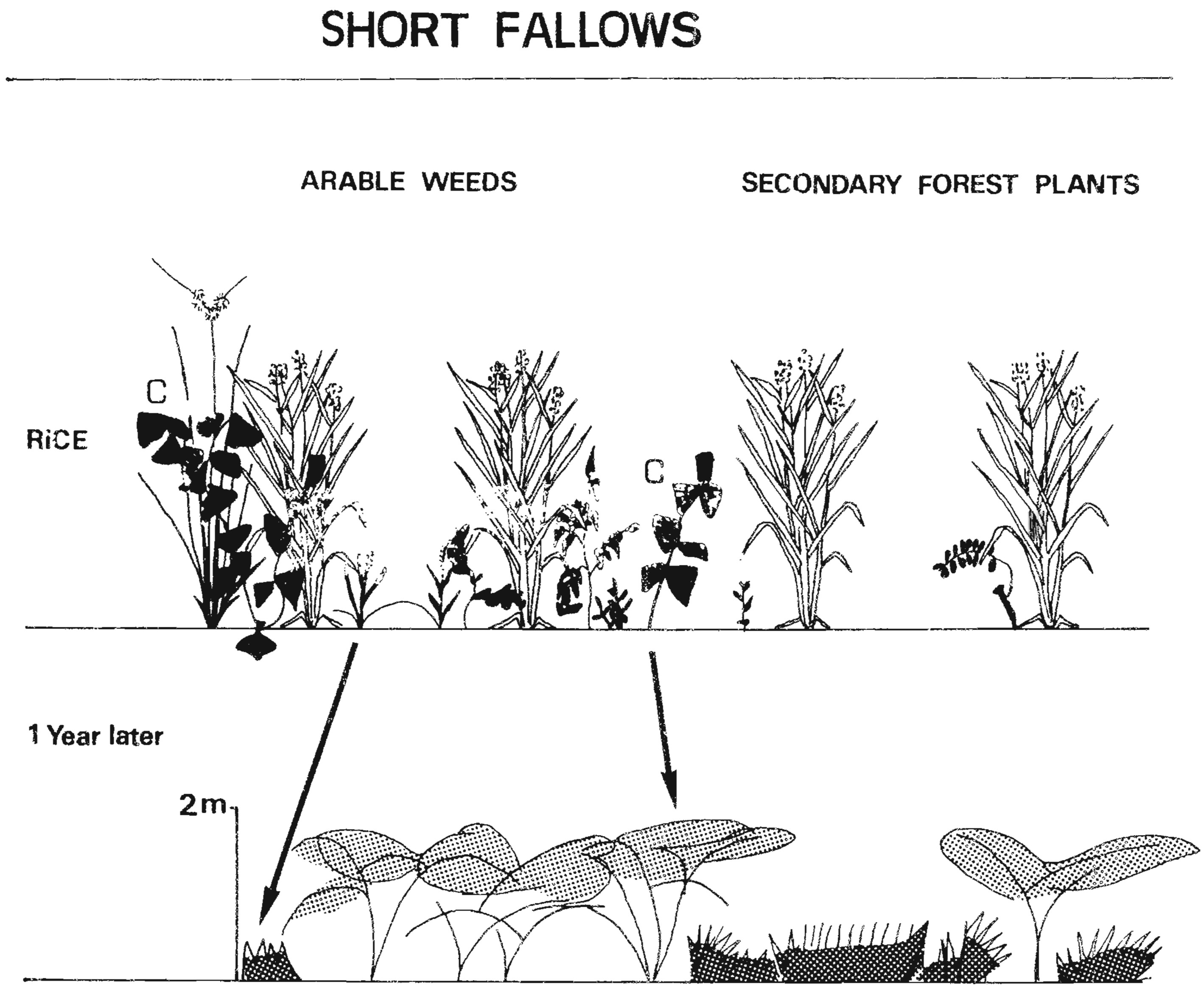


Figure 3. Spontaneous plant growth in Rice planted in a 6 year old fallow.

# SHORT FALLOWS - POORLY DRAINED

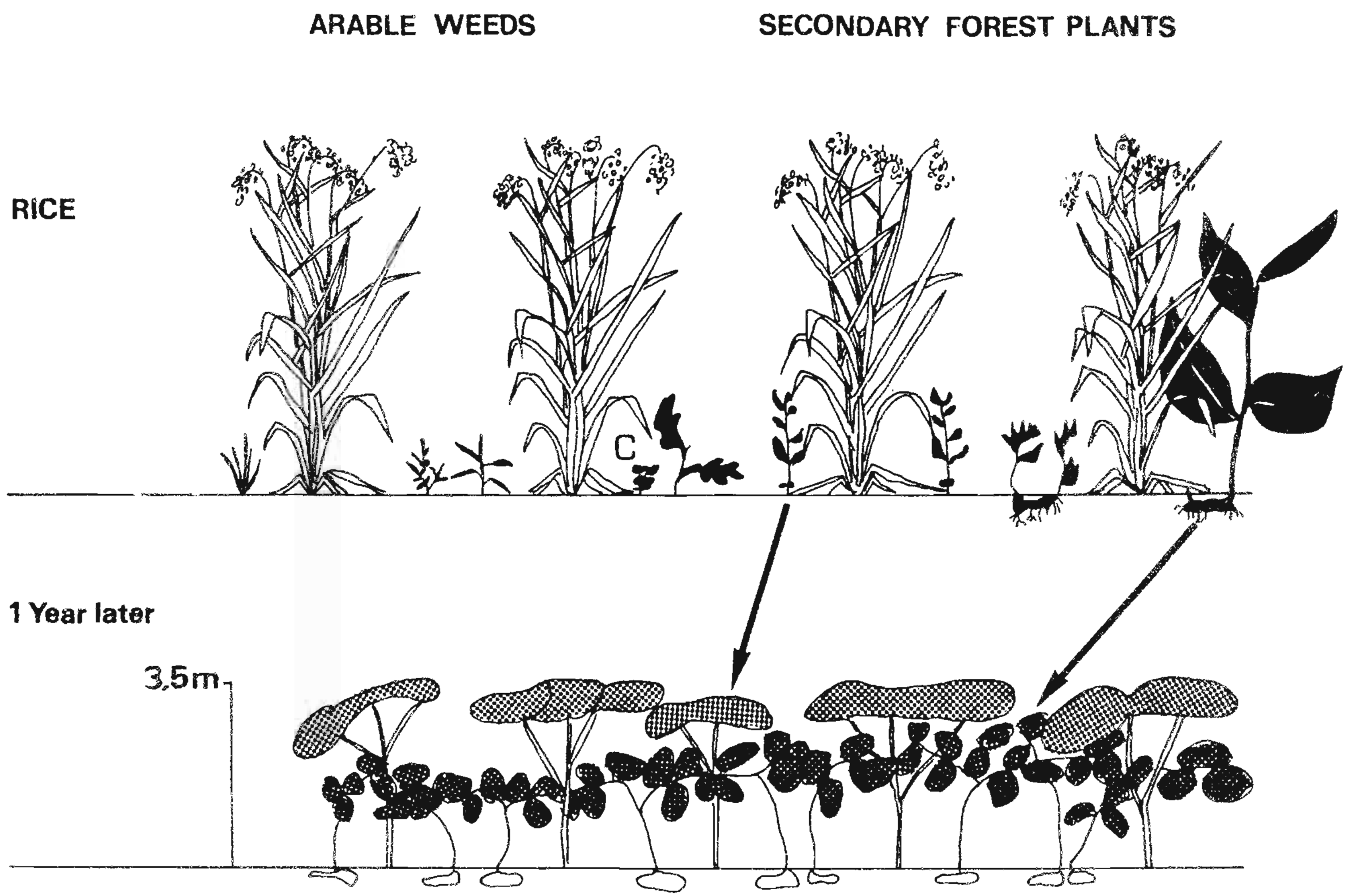


Figure 4. Spontaneous plants, including Marantaceae and *C. odorata* among Rice grown in a 6 year old fallow in porly drained soils.

growth of pioneer trees nor development of *C. odorata* is suppressed. One of the conditions for rice growing is the removal of *C. odorata* seedlings early in the season. It constitutes the only severe threat to starting a fallow vegetation consisting of both pioneer trees and Marantaceae climbers (Fig. 4). It is the resprouting ability of established *C. odorata* plants that would drive out the Marantaceae and make rice cropping impossible.

### Rice - Cocoa

Cocoa and coffee cultivation is widespread although forest people and immigrants use different procedures. Instead of allowing rice fields to revert to forest, cocoa or coffee is planted. Often young trees are interplanted as the rice reaches maturity. Fields are weeded every one or two years. A result of the almost permanent shade is stunted growth of young cocoa. Another consequence is the disappearance of arable weeds and degeneration of *C. odorata.*

Unhealthy adult plantations revert naturally to secondary forest, whereas healthy plantations always have some tree cover since fields were never weeded. In both of these cases, shade is sufficiently dense to prevent colonization by C. *odorata.*

### Cocoa and other Food Crops

Immigrants concurrently plant maize, cassava and yams with cocoa seedlings. By weeding fields several times a year, the seed stock of woody plants is destroyed and resprouting stumps are weakened. Open spaces are created and filled by species with very effective means of dispersal, such as annual weeds and *C. odorata.* These plants will re-seed the field continuously, being checked only by weeding or by canopy formation.

Only a healthy adult plantation provides sufficient shade to keep out *C. odorata.* In plantations where cocoa plants die out, weeding is not carried out. A solid thicket of *C. odorata* forms after a period during which it out-competes grasses and low weeds. In areas with acute land shortage, maize and cassava are cultivated in cocoa plantations that are already dying back.

## Discussion and Conclusion

Small farmers are too poor to use herbicides and have a problem managing weeds in the humid environments where weeds grow and produce seeds continuously. They control weeds by pulling, cutting, and manipulating shade. Shading out weeds by cultivation is a defensive measure against the buildup of weeds. Canopy shade can be used only at the season's end because almost all food crops require open light.

Canopy shade is produced most rapidly where pre-existing tree seeds and stumps simply sprout. The rice shifting cultivation system in Taï is such an example. The same process has been reported from other rain forest areas where upland rice is grown in shifting cultivation (Kochummen & Ng1966, Kunkel 1966, Symington 1933). The success of rice cultivation and low levels of weed infestation including *C. odorata*, are both related to the maintenance of long fallow and short occupation periods. In all these cases, forested land is or was in good supply.

Canopy shade forms more slowly when the viable seeds in the soil are destroyed. Here, post-harvest forest cover is not able to develop from tree seeds since they have been weeded. Vacant spaces in the system are filled by *C. odorata*. In some cases where resprouting plants have been preserved, rapid overhead shade is produced by these forest plants. As shown by this and other studies (Delvaux 1985, Aweto 1981, Zinke *et al.* 1978, Vine 1954), the ability of resprouting plants to exclude and suppress weeds has been used in shifting cultivation systems suffering from land shortage. In Taï and Nigeria (Aweto 1981), *C. odorata* is controlled either by weeding or does not enter the system because it is shaded out rapidly.

Where repeated cutting and burning destroys both the seedbank of trees and the population of resprouting forest plants, canopy shade of forest fallow is replaced by a thicket. The thicket-forming *C. odorata* unbalances the system and whole areas may pass into other systems of land development. This too has been described for Taï (Slaats 1994) and elsewhere (Ahn 1958, Smitinand *et al.* 1978, Zwetsloot 1981).

Unlike shifting cultivators who grow cereals, farmers planting tubers are obliged to clean the forest soil more thoroughly by extra burning, tilling to bury the plant material, and extra weeding because of the longer growing season. Inevitably, they destroy much of the forest seed stock. Thus, farming systems with root or tuber crops are more prone to *C. odorata* infestation than cereal crop systems even when forested land is in good supply. Examples of this have been given by de Foresta & Schwartz (1991), and Uhl & Murphy (1981).

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